

Blue carbon and kelp ecosystems

NIVA – research for a sustainable future

SKLEC-NIVA OSLO SEMINAR

Oslo CIENS Park, Oslo, Norway

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by Kasper Hancke et al.



Content

1. The ecological relevance of kelp forest ecosystems
2. Potential implications of kelp farming
3. Role of kelp in Blue Carbon budgets



The ecological relevance of kelp forest ecosystems

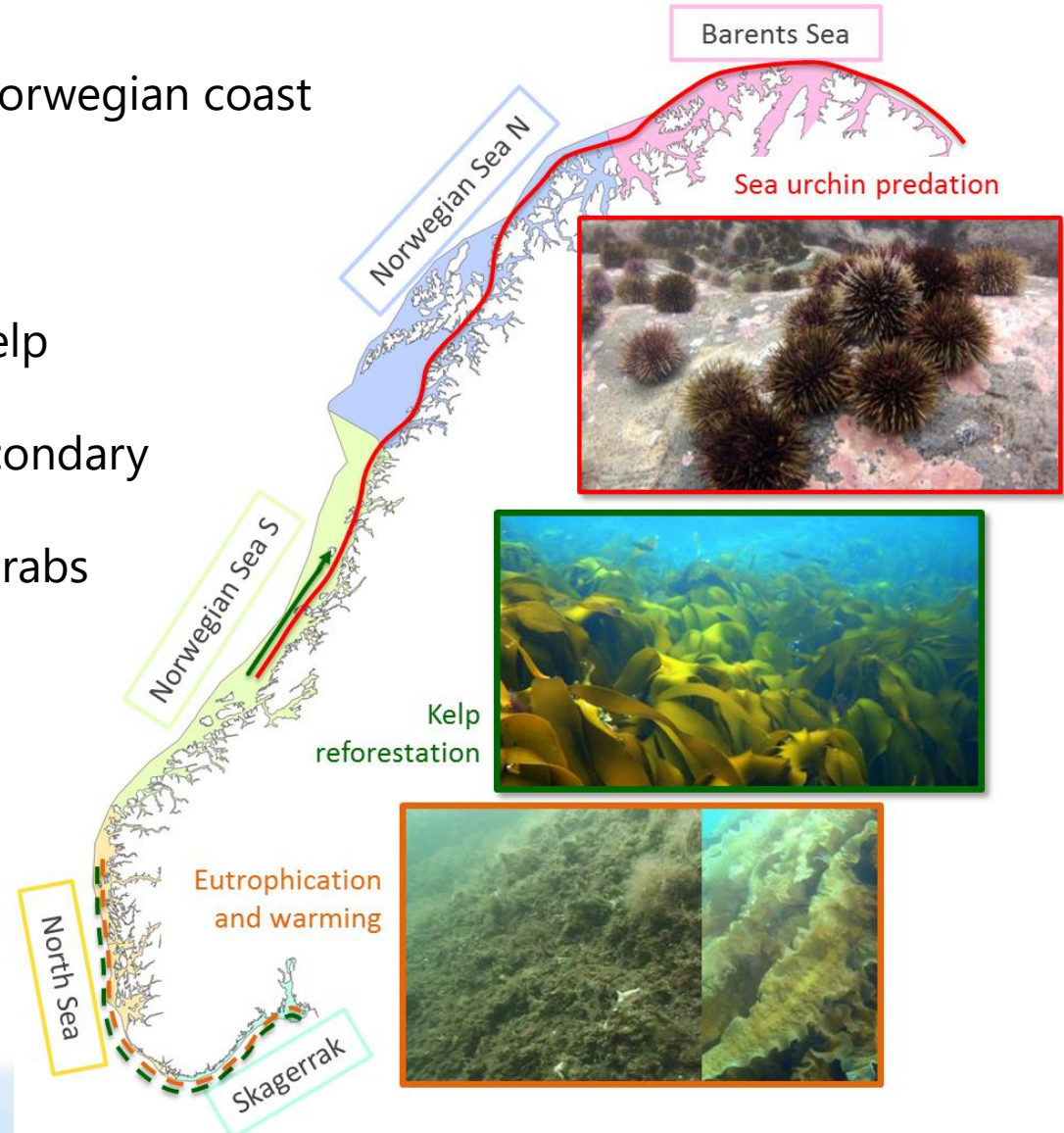
- 9000 km² of kelp forest on Norwegian coast
- ~40 mill. ton of kelp carbon

Kelp forest ensure

- Coastal primary production (kelp biomass)
- Increasing biodiversity and secondary production
- Increase harvestable fish and crabs



Visit
Norway



Gundersen et al 2010, Christie et al 2009, subm.

Kelp forest ecology in times of climate change



+ ocean
warming

Norwegian Sea

67°50' N

1990-2015
530 km

63°30' N



Processes:

- Kelp forests are recovering
- Sea urchins decline
- Oceans warm
- Crabs increase

~8000 km² of barren grounds potentially regrowth
- equivalent to a gain of **36 million tons CO₂** fixation

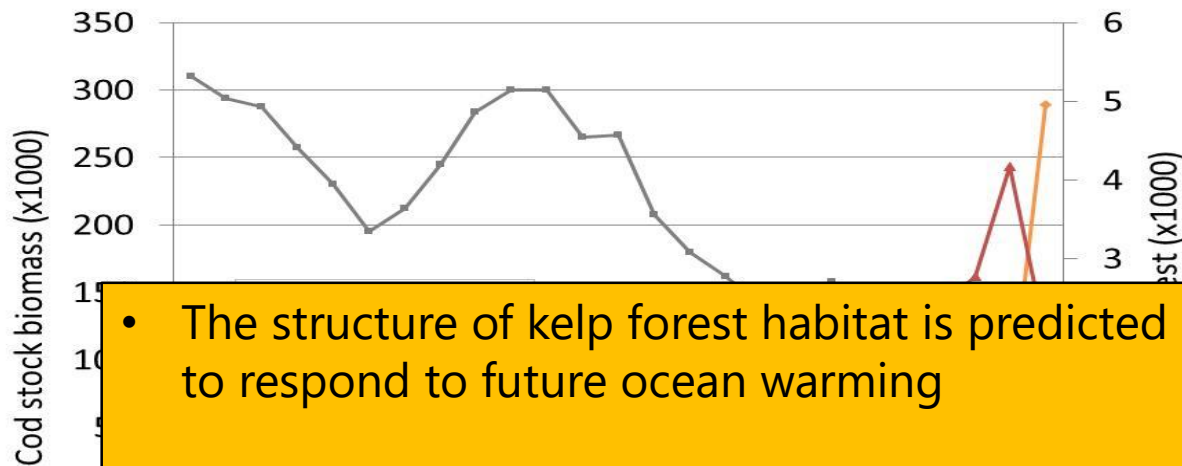
(Gundersen et al 2011, 2015)

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2009 DigitalGlobe
Image © 2009 TerraMetrics
Image IBCAO

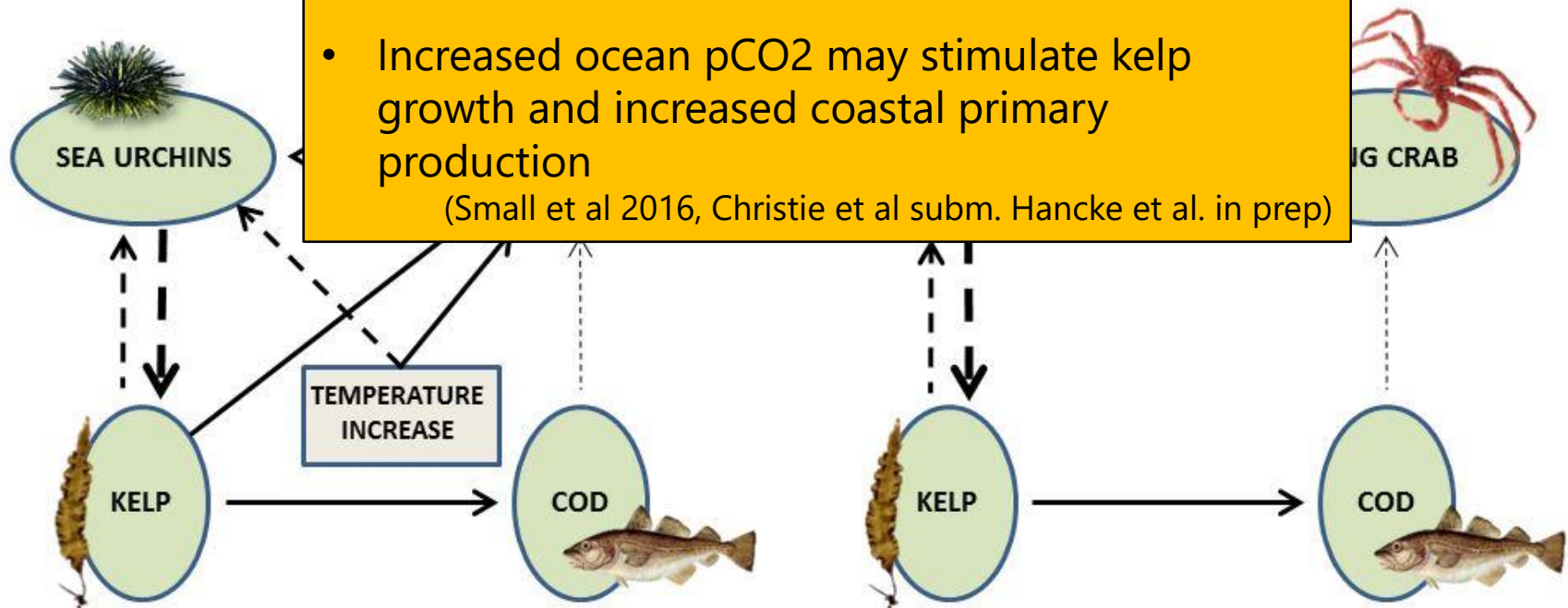
64°40'25.04" N 14°59'06.33" E elev 352 m

©2009 Google
Christie et al 2009, subm.

Øyehøyde 2033.52 km



- The structure of kelp forest habitat is predicted to respond to future ocean warming
 - Kelp forest re-growth (reforestation) occurs as a (likely) response of ocean warming
 - Increased ocean pCO₂ may stimulate kelp growth and increased coastal primary production
- (Small et al 2016, Christie et al subm. Hancke et al. in prep)



Industrial kelp farming: An strategic initiative



Markets opportunities

1. Human food

- Sea vegetables, snacks
- Salt replacement
- Flavour
- Texturizer



2. Health & nutrition (humans and animals)

- Gut health (fibers, prebiotics)
- Immune stimulation
- Anti-oxidants
- Anti-inflammatory
- Anti-biotic
- Protein
- Vitamins
- Minerals
- Fatty acids
- Skin health (cosmetics)
- Animal fur and mucus health
- Pharmaceuticals/bioactives



3. Plant health & nutrition

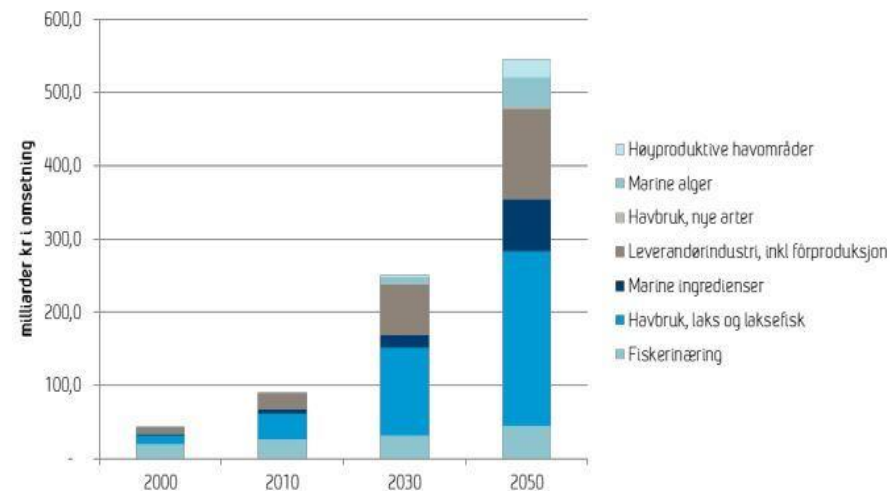
- Growth promoters
- Plant defense
- Macronutrients (N, P, K)
- Micronutrients (Fe, Ca, Cu)
- Trace elements



4. Specialty chemicals



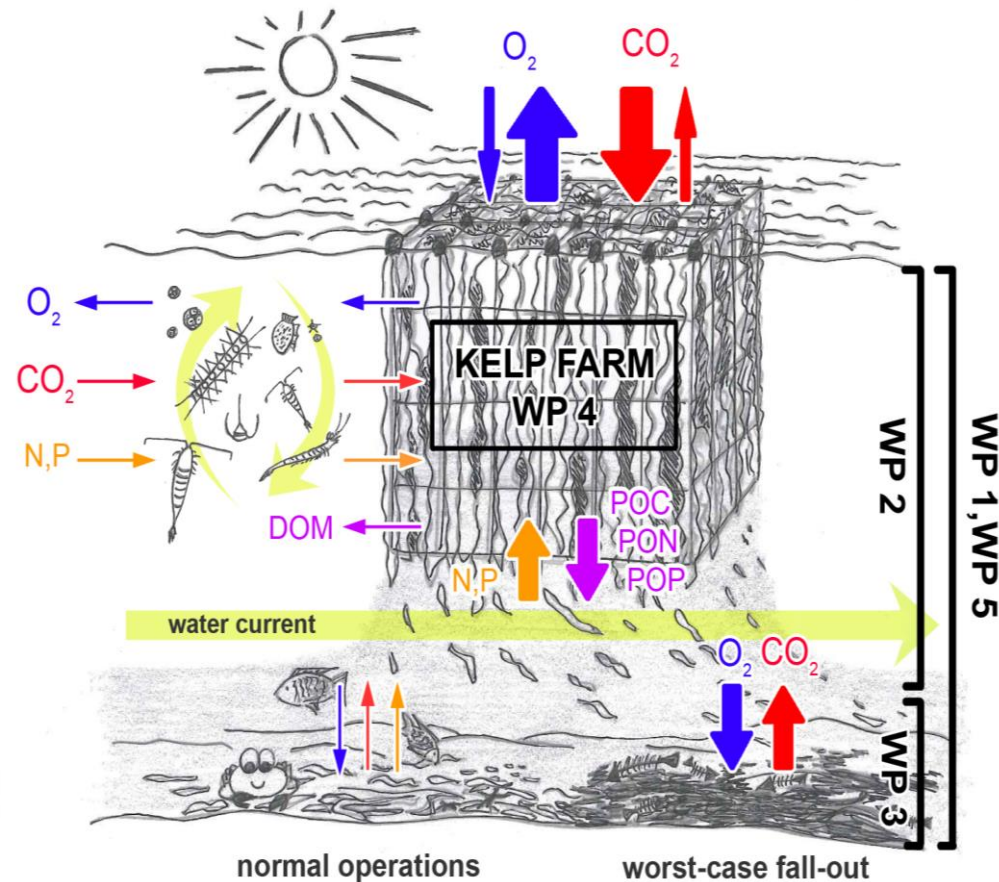
Scenario 2050: Potensial for marin verdiskaping



Industrial kelp farming: Potential impacts on coastal ecosystems (KELPPRO)

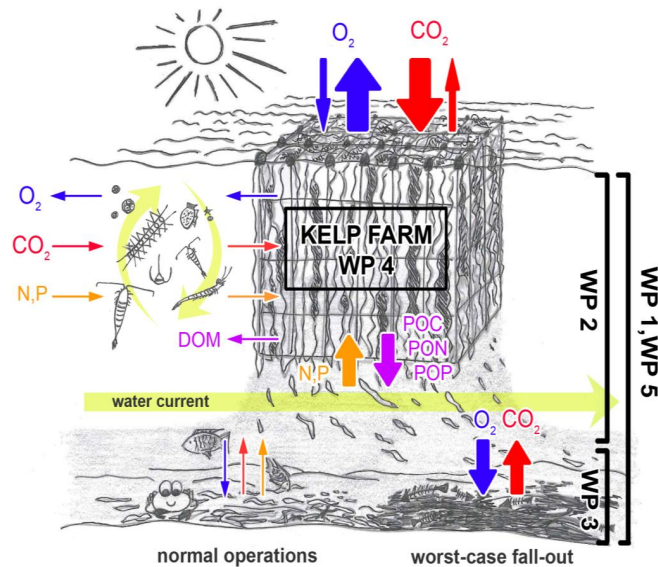
Research scenarios:

- Industrial kelp cultivation scenarios
- Effects on sea floor ecosystems
- Effects on open water ecosystems
- Industrial kelp facilities as 'artificial kelp forests'



Hancke et al in 2016, in prep

Kelp industrial production: Potential impacts on coastal ecosystems (KELPPRO)



Positive impacts are

- kelp **uptake of nutrients and CO_2** , reducing marine eutrophication and CO_2 concentration (i.e. reducing ocean acidification).
- **increased primary production**
- Promote **biodiversity**

Negative impacts are

- **depletion** of limited nutrients or the **depositing** of large quantities of detached kelp on the seafloor, leading to
- **poor environmental conditions,**
- **oxygen deficiency,**
- and change in natural **biodiversity.**

Hancke et al in 2016, in prep

Kelp detritus (detached kelp) drifting and settling on the the sea floor





Blue carbon sinks are built by plants and trees (otherwise known as angiosperms such as mangroves, salt-marsh plants and seagrasses) but the coastal ocean also contains vast areas covered by algal beds. Most macroalgal beds (including kelp forests) do not bury carbon, as they grow on rocky substrates where burial is impossible.

A RAPID RESPONSE ASSESSMENT

BLUE CARBON

THE ROLE OF HEALTHY OCEANS IN BINDING CARBON

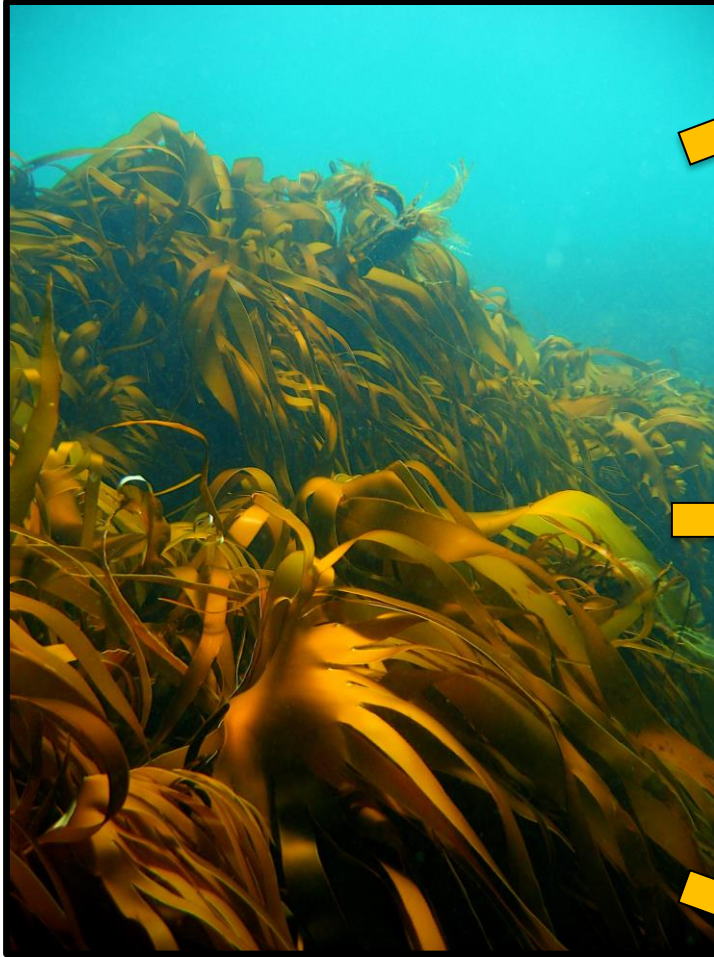


Modified after Nellemann
m.fl. 2009

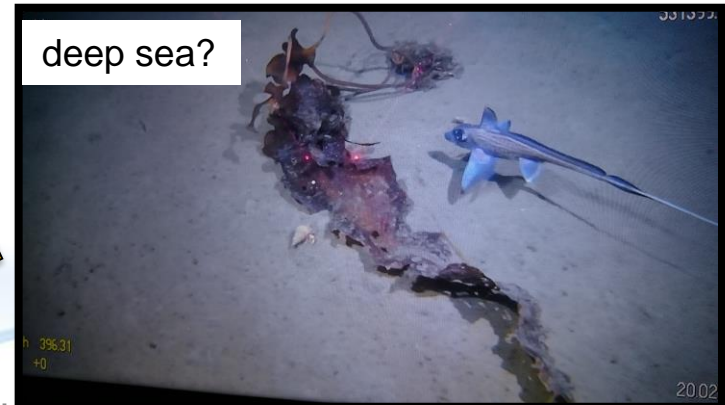
The carbon budget

Production: 150 – 512 g C m⁻²

(Krumhansl & Scheibling 2011)

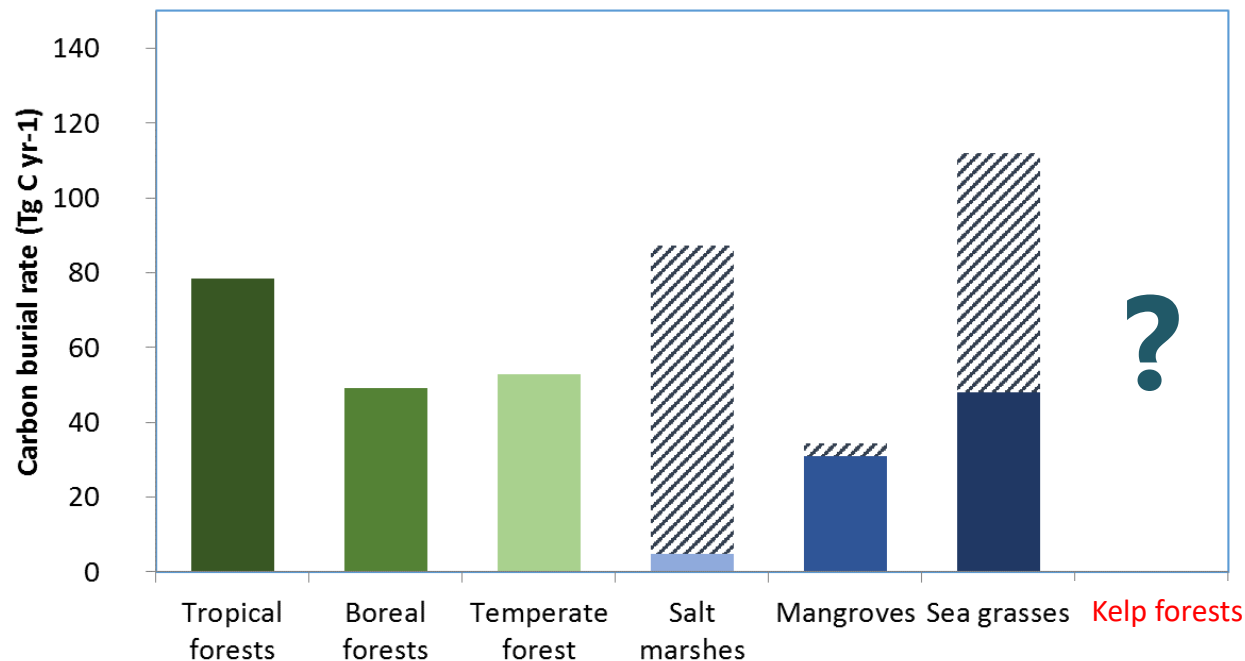


Photographs: K. Filbee-Dexter and T Bakken



Marine versus terrestrial carbon storage

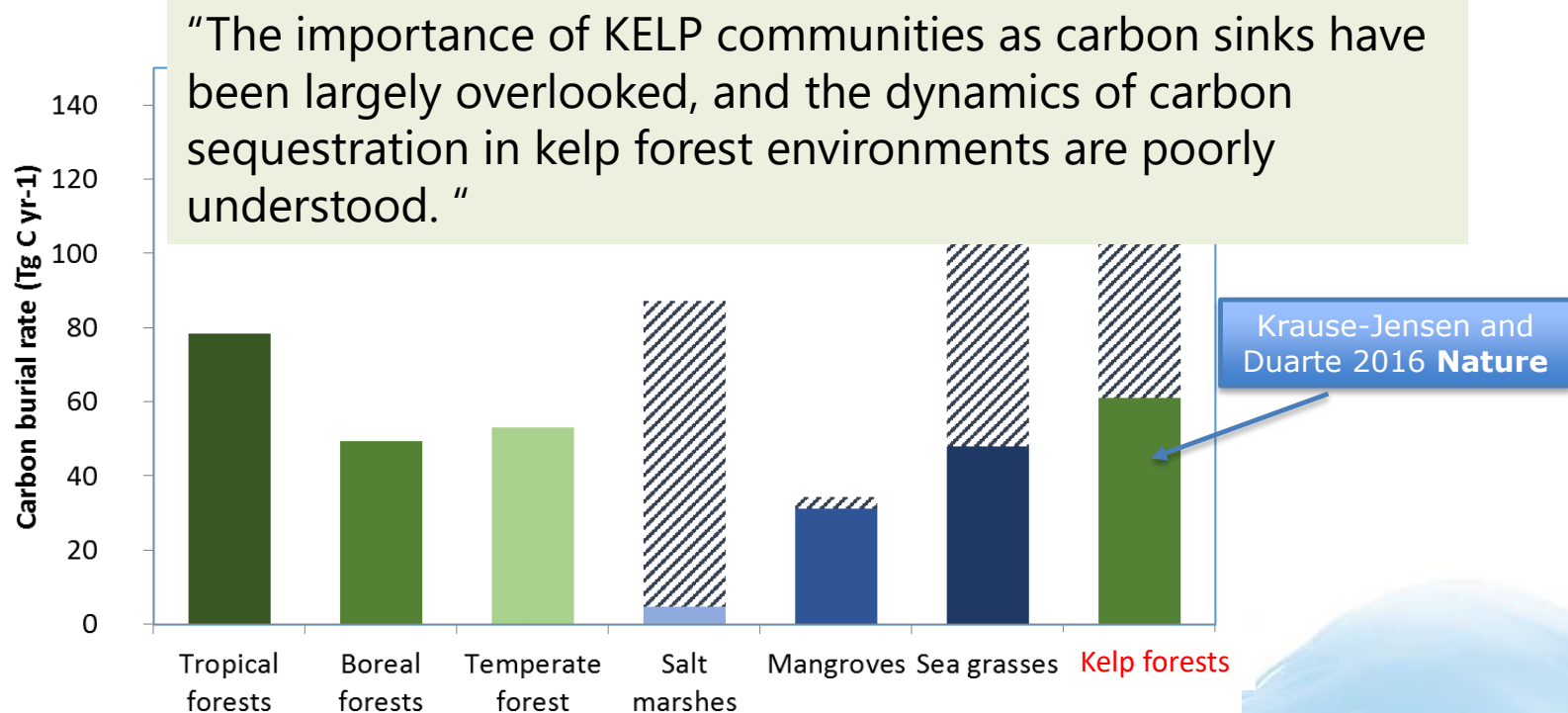
Globally, the marine carbon sequestration is in scale with the terrestrial



Data from McLeod m.fl. 2011

Marine versus terrestrial carbon storage

Globally, the marine carbon sequestration is in scale with the terrestrial



Data from McLeod m.fl. 2011 and
Krause-Jensen and Duarte 2016

CONCLUSIONS

Kelp ecosystem importance

- Increased primary production (kelp biomass)
- Increasing biodiversity and secondary production
- Increase harvestable fish and crabs

Kelp farming implication

- **Positive:** nutrients and CO₂ uptake, climate mitigation
- **Negative:** nutrients depletion, oxygen deficiency and poor environmental conditions

Strategic research activities at NIVA

- Role of kelp forests in the 'Blue Carbon' budget
- Quantitative understanding of kelp carbon capture, turnover and sequestration
- Quantifying ecosystem services (harvest, fishery, tourism etc.)